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WIRELESS INTERNAL SHIP COMMUNICATIONS SYSTEM TEST RESULTS ABOAR--ETC(U)
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AD-A032 405

WIRELESS INTERNAL SHIP COMMUNICATIONS SYSTEM TEST RESULTS ABOARD U. S. NAVY DESTROYER ESCORT DE-1094 (USS PHARRIS)

GOULD, INCORPORATED
SHADY SIDE, MARYLAND

30 JUNE 1975

ADA032405

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FINAL REPORT

WIRELESS INTERNAL SHIP COMMUNICATIONS SYSTEM TEST RESULTS ABOARD U.S. NAVY DESTROYER ESCORT DE - 1094 (USS PHARRIS)

30 June 1975

PREPARED FOR

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
ANNAPOLIS, MARYLAND 21402

CONTRACT N00024-74-C-1243

BY
GOULD, INC.
CHESAPEAKE INSTRUMENT DIVISION
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C.I.C. PROJECT 74154

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ADMINISTRATIVE INFORMATION

This work has been conducted by Chesapeake Instrument Corporation, Shady Side, Maryland, for the Naval Ship Research and Development Center, Annapolis, Maryland, under contract number N00024-74-C-1243.

This report has been prepared by Propulsion Dynamics, Inc., Annapolis, Maryland under a subcontract from Chesapeake Instrument Corporation.

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Wireless Internal Ship Communications System Test Results
Aboard U.S. Navy Destroyer Escort DE-1094 (USS Pharris)

by
C.J. Rubis & J.S. Mikuckis

INTRODUCTION

A wireless communications system independent of Ship's power and using portable hand-held transceivers has been installed aboard the USS PHARRIS, DE1094. This system utilizes a slotted coaxial cable as the primary transmission medium. Radio frequency energy from the portable transceivers couples into the cable through the slots. In the same manner, radio frequency energy within the cable leaks out and is received by the portable transceivers in areas traversed by the cable. Thus, the cable serves as a passive, reciprocal RF energy transmission medium covering any number of ships compartments. The slotted coaxial cable used for this system was RX4-3, Radiax,* manufactured by the Andrew Corporation, Orland Park, Illinois.

A preliminary cable routing analysis, based on ship's drawings, was completed and a report issued on July 29, 1974 ("Interim Memorandum Report for Shipboard Wireless Intercommunication System - Preliminary Cable Routing Analysis, "Chesapeake Instrument Corporation, July 29, 1974).

On the 1st and 2nd of August, 1974, a survey was conducted aboard the USS PHARRIS in order to develop a detailed cable installation plan.A report was issued on August 12, 1974 ("Interim Memorandum Report for Shipboard Wireless Intercommunication System - Cable Installation Plan, "Chesapeake Instrument Corp., August 12, 1974). The actual cable installation followed soon after the issuance of the installation plan.

A report consisting of the recommended detailed system test plan was issued on September 3, 1974 ("Interim Memorandum Report for Shipboard Wireless Intercommunication System - Radiax System Design and Test Plan," Chesapeake Instrument Corp., Sept. 3, 1974).

* Andrew Corporation trade-name

System testing took place during May 8-11, 1975 aboard the USS PHARRIS docked at the Naval Shipyard in Portsmouth, Virginia. The objectives of the system tests were as follows:

- Determine coupling loss for various locations served by the cable and the minimum operating power level.

- Determine capability of the system as an internal communication system, including such items as intelligibility, noise, interference between channels, interference from other sources, etc.

- Conduct interference tests to determine the extent of interference between the Radiax system and other ship systems.

This report describes the system tests conducted and discusses the data obtained. Other pertinent data obtained at other times are also included.

INSTRUMENTATION

The following is a list of instruments used during the performance of system tests:

Voltmeters, dc, digital - J. Fluke, model 427

Microammeters, dc - Weston, model 622

RF attennators - Jerrold

Transceivers, vhf - Motorola, model HT220

Power supplies, dc, regulated - Power Mate, model BP-20D

RF power meters - Hewlett - Packard, model 435A

The receiver sections of Motorola HT220 hand-held transceivers were modified by Chesapeake Instrument Corporation in order to provide an extra feature of received signal strength measurement. This was done by installing a detector circuit at the RF output point of the second mixer stage. The modification is shown in figure 1 (dotted). The corresponding second mixer output point and ground locations on the transceiver's printed-circuit card are shown in figure 2.

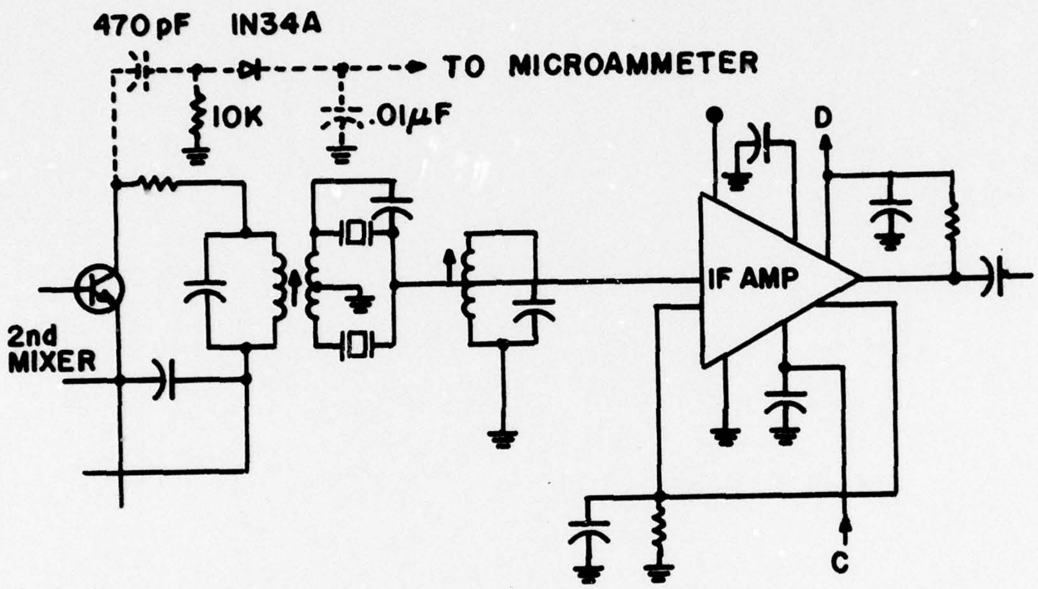

Figure 1
Modification to the Motorola HT220 Transceivers
(Schematic Diagram)

The detector circuit rectifies the RF signal output from the second mixer stage and the resultant rectified dc voltage is used to drive a microammeter for the received signal strength indication. Each of the three Motorola HT220 units (serial numbers USN 755, USN 756, and USN 757) were calibrated individually in terms of received signal power in dBw (decibels with respect to 1 watt). The calibration curves of the three HT220 units are shown in figures 3 to 5.

It is important to recognize that the lowest input power level (-125 dbw) shown on these curves is not the sensitivity threshold of these receivers which have a minimum detected power level of about -148 dBw corresponding to about 0.35 microvolts across 75 ohms. Because of the steepness of these calibration curves poor detector current resolution would result for low input power level changes, therefore signal level measurements were made at power levels generally well above -120 dBw.

The calibration curves are the averaged results of three sets of calibration readings for each transceiver.

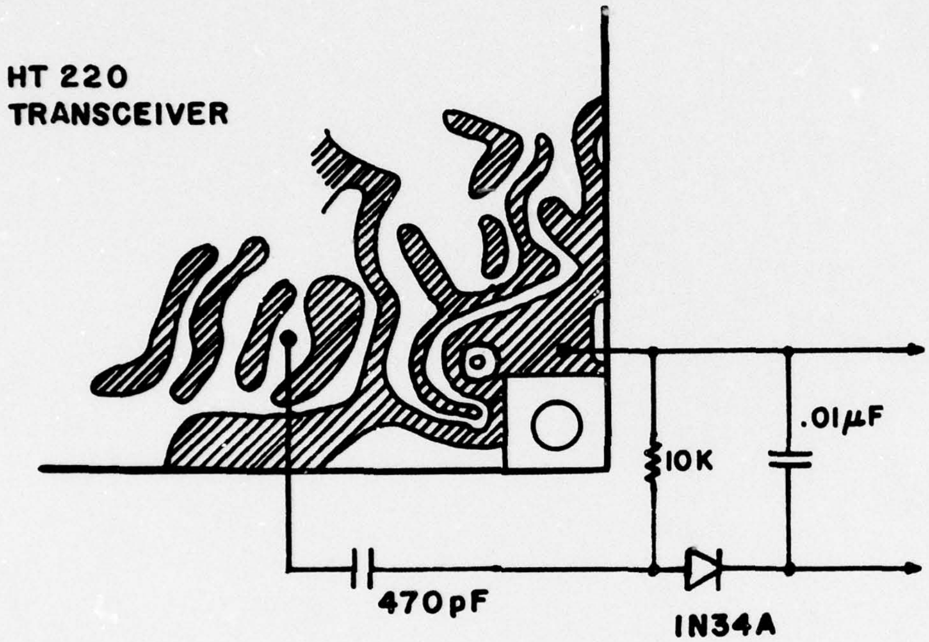

Figure 2
Modification to the Motorola HT220 Transceivers
(Printed-Circuit Card Layout)

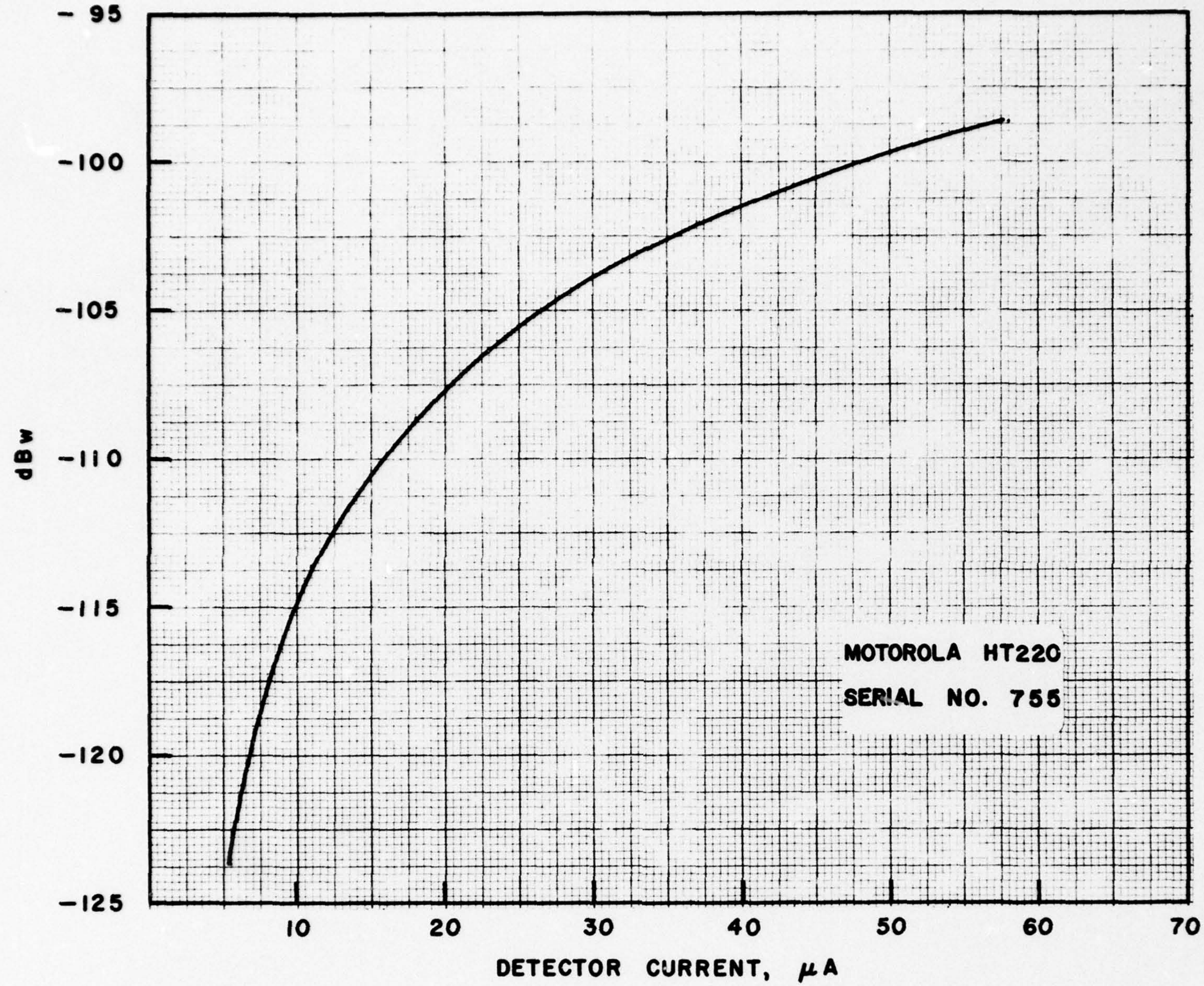

Figure 3
Receiver Input Power Versus Receiver Detector Current

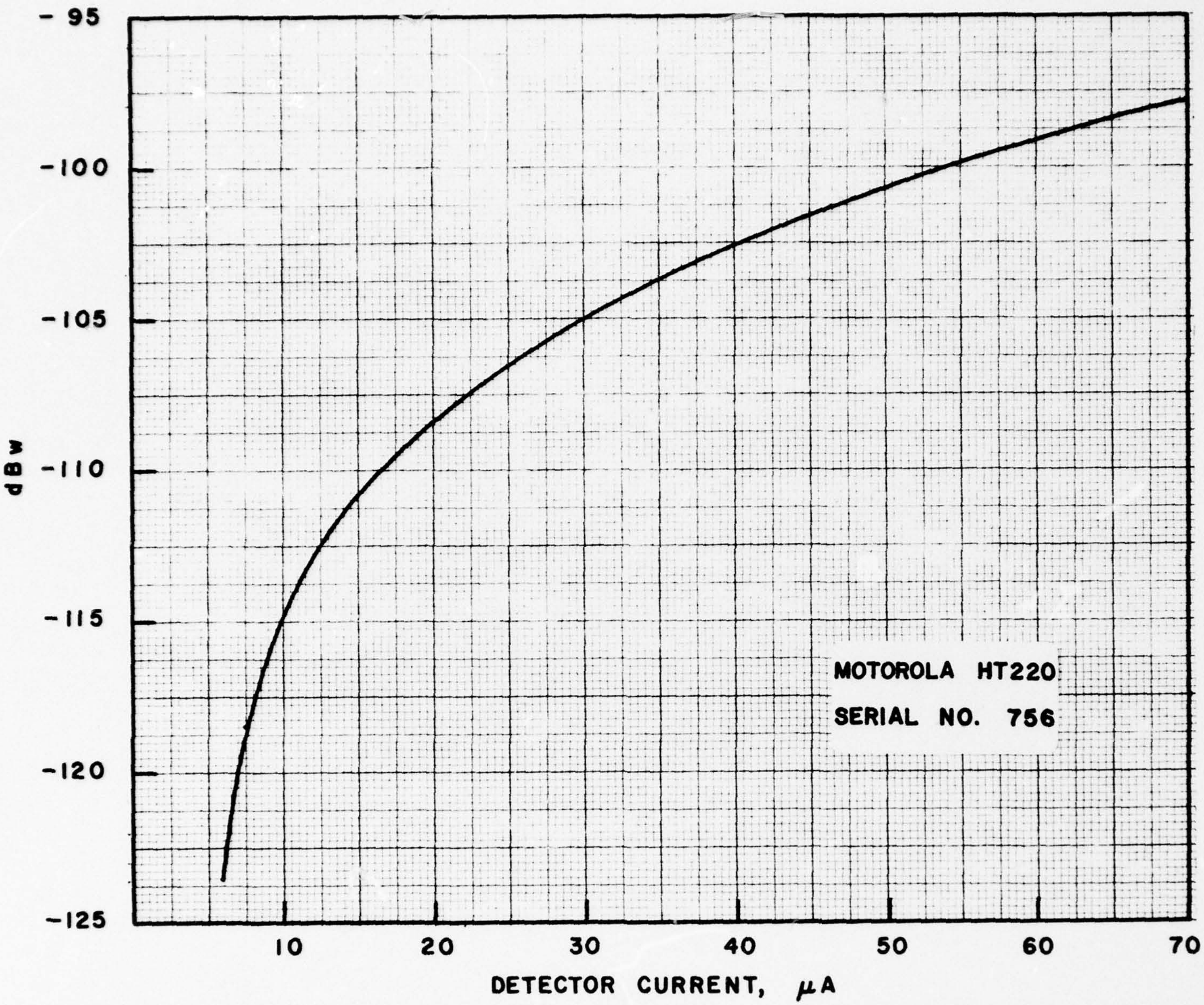

Figure 4
Receiver Input Power Versus Receiver Detector Current

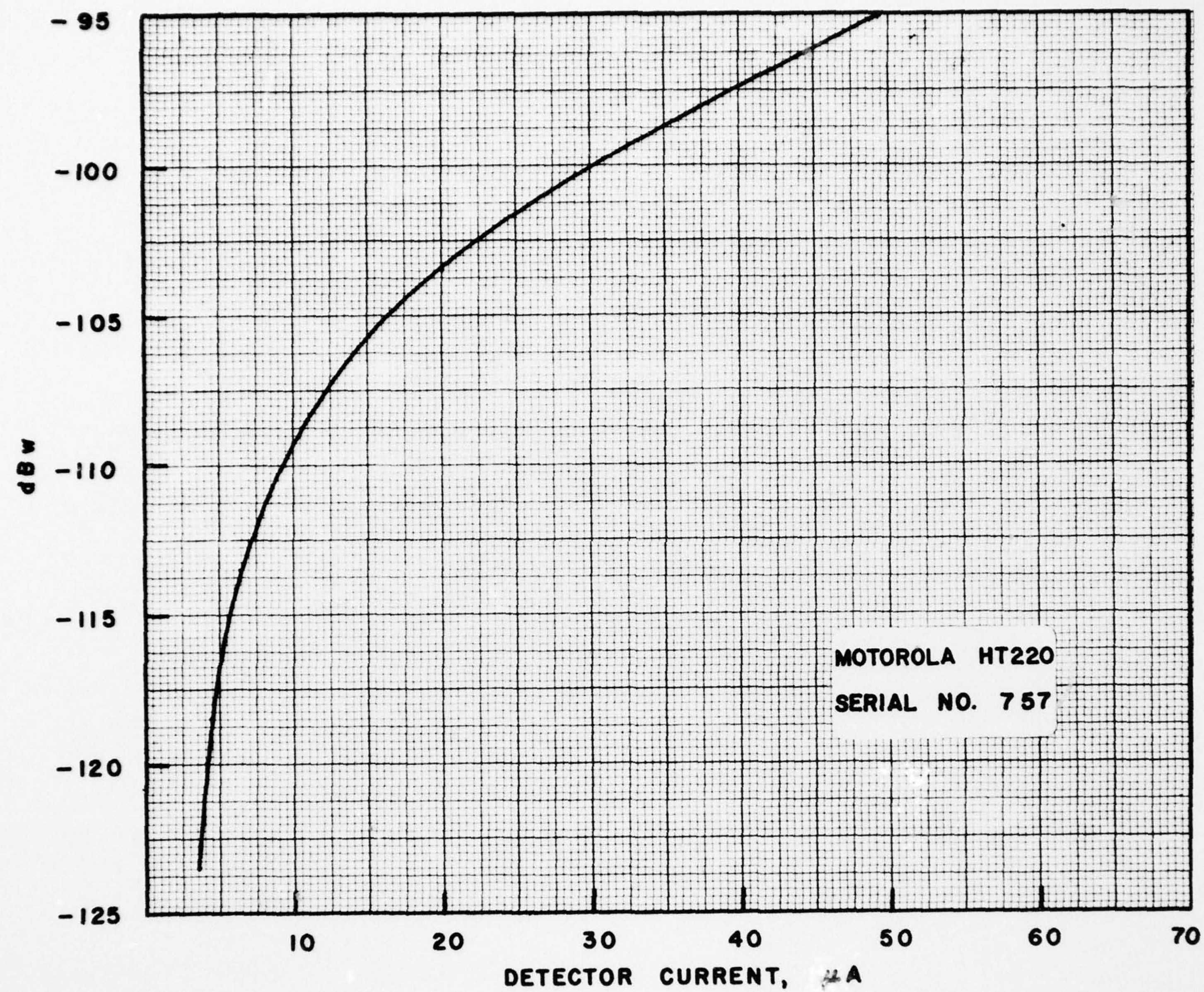

Figure 5
Receiver Input Power Versus Receiver Detector Current

TESTING PROCEDURES

Determination of Cable Attenuation

A value of cable attenuation is required for the coupling loss calculations which are the major quantitative results of these tests. Cable attenuation was determined as follows: Both power splitters were removed from each route (Repair #3 and EOS) and two sections of the cable joined using connectors while the branch line was left unconnected. The aft and forward cable routes were connected together at shaft alley #1 resulting in a total length of 991 feet for the two routes.

The antenna of one HT220 transceiver was connected to the power meter and the power supply voltage powering the transceiver was reduced until the transmitter output power into a 50-ohm load was reduced to 0.25 watt. The antenna output was then connected directly into the Radiax cable at the OOD station (1-121-0-L), which is the aft extreme of the combined aft-fwd cable. The antenna of the second HT220 transceiver was connected directly into the Radiax cable in series with an external attenuator at DCC (2-54-0-Q), which is the forward extreme end of the combined aft-fwd cable. The power supply powering the second unit was adjusted for rated voltage in order to assure calibrated receiver sensitivity. The general test setup is shown in Fig.6. A dc microammeter was then connected to the output of the receiver detector and the attenuator setting adjusted for a microammeter reading which corresponded to a convenient point on the receiver calibration curve. From the attenuator setting, microammeter reading and known input power at the other end of the cable, the cable attenuation was determined as follows:

$$dB_{cable\ loss} = dBw_T - dBw_R - dB_{atten}$$

where $dB_{cable\ loss}$ = cable attenuation, dB

dBw_T = transmitted power into cable, dBw

dBw_R = received power at end of cable, dBw

dB_{atten} = attenuator box setting, dB

The data for this measurement were as follows:

$dBw_T = 10 \log (0.25 \text{ watts}) = -6$ dBw

$dB_{atten} = 30$ dB

$dBw_R = -101$ dBw (from calibration curve)

Therefore, $dB_{\text{cable loss}} = -6 - (-101) - 30 = 65$ dB

or, cable attenuation/100 ft $= \frac{65 \text{ dB}}{991 \text{ ft}} \times 100 = 6.6$ dB/100 ft.

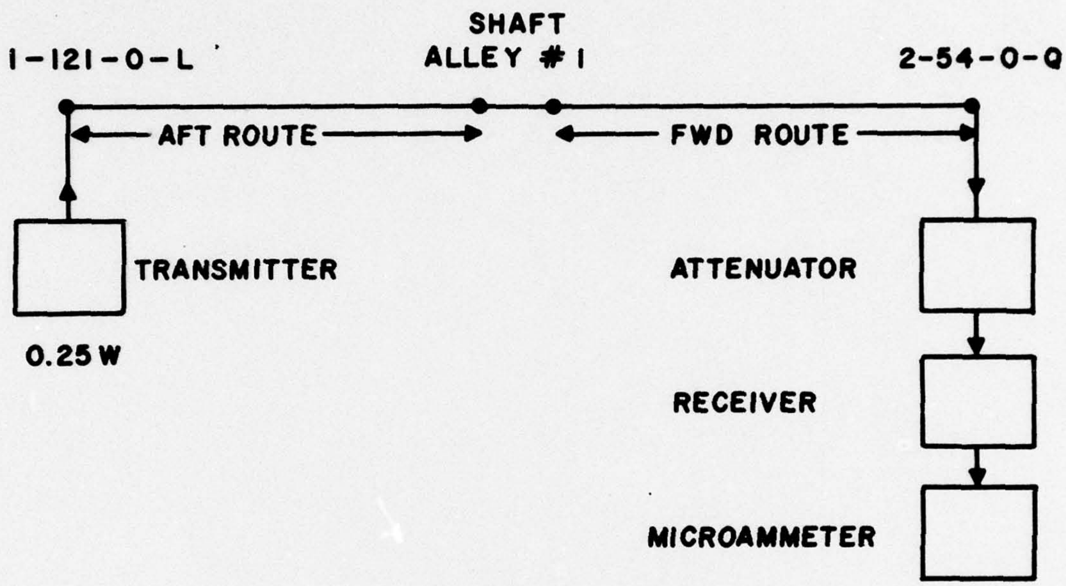

Figure 6
Test Setup for Cable Attenuation Determination

Determination of Coupling Loss

Coupling loss measurements were made between various compartments for both one-way and two-way coupling loss conditions. One-way coupling loss is the signal attenuation between the Radiax cable and the receiver input terminals (including the transceiver antenna loss) with one transceiver hard wired to the Radiax cable. Two-way coupling loss is the total signal attenuation between the Radiax cable and the input/output terminals of two portable transceivers.

The coupling loss is calculated from the following equation:

$$\text{Coupling Loss} = dBw_X - dBw_R$$

where dBw_X = power in the cable at receiver location

dBw_R = power received at transceiver (using calibrated detector current)

But $dBw_X = dBw_T - dB_{atten} - dB_{cable\ loss}$

The following is an example of a coupling loss calculation using the data obtained in test A1.

$P_T = 0.25$ watt, $dBw_T = 10 \log 0.25 = -6$ dBw

Detector Current = 22 microamps

L_{cable} = 339 feet (between EOS and DCC)

Cable Attenuation= 6.6 dB/100 ft

Since a power splitter is used at the EOS location, an additional 3 dB loss must be added to the total cable loss value.

$$dB_{cable\ loss} = \left(\frac{339}{100} \times 6.6\right) + 3 = 25.4 \text{ dB}$$

dB_{atten}= 30 dB (from A1 data sheet)

$dBw_X = -6 - 30 - 25.4 = -61.4$ dBw

$dBw_R = -103$ dBw (from figure 5)

Coupling loss = -61.4 - (-103) = 41.6 dB

The transmitter output power of 0.25 watt into a 50-ohm load was obtained by reducing the power supply voltage powering the HT220 unit at the transmitter end (EOS). Rated HT220 supply voltage was maintained at the receiver end (DCC) for calibrated receiver sensitivity and audio output level.

TEST DATA

The data in this section was taken during system tests aboard the destroyer escort USS PHARRIS. Coupling losses were calculated for each test where sufficient data was available. The data for the majority of tests were obtained with a transmitter power of 0.25 watt, operating at approximately 140 MHz. Antenna orientation was vertical for all portable measurements, i.e., whenever a transceiver was not hard-wired to the Radiax cable.

The attenuator was connected in series with either the receiver antenna or in series with the transmitter hard-wired to the Radiax cable and the setting adjusted for a reasonable micro-ammeter reading. The receiver power, dBw_R, was then obtained from an appropriate receiver calibration curve (figures 3 to 5). The value of coupling loss was calculated using the method described earlier. Telescopic, fully extended, transceiver antenna (approx. 24" long) were used during most of the tests; data taken with the "heliflex" antenna are indicated by a notation under the related test. Signal quality refers to a subjective interpretation by the operator(s). Several test were found to contain unsufficient data for coupling loss computation, others contained receiver detector current readings outside the calibration curves; these measurements have not been included in this report. The "X" series of test measurements have no quantitative data; however, they are included in this report for system effectiveness evaluation. All tests were conducted under an approximate material condition ZEBRA (all ship's hatches and doors closed); however, there were numerous instances where this condition was not strictly maintained due to other activities of ship's personnel opening doors and hatches at random and other cases where cables passed through hatches and doors during dockside work preventing their closing.

The data recorded during system testing aboard the ship is reproduced in the tables that follow. Test numbers refer to individual original data sheets and are included for reference purposes only. Coupling losses for series "X" tests were not calculated because no quantitive data were taken for this series.

TEST A1 DATE 5/8/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	EOS	DCC
Location Within Compartment		at table
Closest Distance to RADIAX, ft.		34"
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	22	
Receiver Input Power, dBw	-103	
Calculated Coupling Loss	41.6 dB	

TEST A3 DATE 5/8/75 TIME 2200

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	DCC
Location Within Compartment	aft	at table
Closest Distance to RADIAX, ft.	6'	34"
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	47	
Receiver Input Power, dBw	-96	
Calculated Coupling Loss	67.6 dB	

TEST A4 DATE 5/8/75 TIME 2210

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	DCC	EOS
Location Within Compartment	aft	at table
Closest Distance to RADIAX, ft.	34"	6'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	75	
Receiver Input Power, dBw	-97	
Calculated Coupling Loss	66.8 dB	

TEST A5 DATE 5/8/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	EOS	Aux Mach Rm #1
Location Within Compartment		turbine 1C
Closest Distance to RADIAX, ft.		9'
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	45	
Receiver Input Power, dBw	-97	
Calculated Coupling Loss	43.8 dB	

TEST A6 DATE 5/8/75 TIME 2315

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	H	P
Compartment	Aux Mach Rm #1	EOS
Location Within Compartment		at table
Closest Distance to RADIAX, ft.		6'
Signal Quality		good
Attenuator Setting, dB	40	
Receiver Detector Current, μA	35	
Receiver Input Power, dBw	-102.5	
Calculated Coupling Loss	40.5 dB	

TEST A8 DATE 5/8/75 TIME 2310

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Aux Mach Rm #1	EOS
Location Within Compartment	turbine 3	at table
Closest Distance to RADIAX, ft.	9'	6'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	35	
Receiver Input Power, dBw	-102.5	
Calculated Coupling Loss	80.5 dB	

TEST A9 DATE 5/8/75 TIME 2335

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	EOS	Shaft Alley #1
Location Within Compartment		4" from ladder on water tank
Closest Distance to RADIAX, ft.		18"
Signal Quality		good
Attenuator Setting, dB	40	
Receiver Detector Current, μA	12	
Receiver Input Power, dBw	-108	
Calculated Coupling Loss	53.7 dB	

TEST A10 DATE 5/9/75 TIME 0035

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	H	P
Compartment	Shaft Alley #1	EOS
Location Within Compartment		at table
Closest Distance to RADIAX, ft.		6'
Signal Quality		good
Attenuator Setting, dB	40	
Receiver Detector Current, μA	45	
Receiver Input Power, dBw	-101	
Calculated Coupling Loss	47.9 dB	

TEST A11 DATE 5/9/75 TIME 0010

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	Shaft Alley #1
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.	6'	2'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	22	
Receiver Input Power, dBw	-102.7	
Calculated Coupling Loss	91.4 dB	

TEST A12 DATE 5/9/75 TIME 0020

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Shaft Alley #1	EOS
Location Within Compartment		at table
Closest Distance to RADIAX, ft.	2'	6'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	35	
Receiver Input Power, dBw	-102.5	
Calculated Coupling Loss	89.4 dB	

TEST A13 DATE 5/9/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	EOS	Electric Central
Location Within Compartment	at table	middle of switchboard
Closest Distance to RADIAX, ft.		4'
Signal Quality		good
Attenuator Setting, dB	40	
Receiver Detector Current, μA	21	
Receiver Input Power, dBw	-103	
Calculated Coupling Loss	36.2 dB	

TEST A14 DATE 5/9/75 TIME 0135

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	Electric Central
Location Within Compartment	at table	middle of switchboard
Closest Distance to RADIAX, ft.	6'	4'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	60	
Receiver Input Power, dBw	-92.5	
Calculated Coupling Loss	68.7 dB	

TEST A15 DATE 5/9/75 TIME 0140

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	EOS	Fwd Blower Rm #1
Location Within Compartment	at table	between blowers, 3' from fwd bulkhead
Closest Distance to RADIAX, ft.		8'
Signal Quality		good
Attenuator Setting, dB	50	
Receiver Detector Current, μA	50	
Receiver Input Power, dBw	-95	
Calculated Coupling Loss	31.8 dB	

TEST A17 DATE 5/9/75 TIME 0230

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	EOS	Fwd Blower Rm #2
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.		9'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	44	
Receiver Input Power, dBw	-96.5	
Calculated Coupling Loss	85.4 dB	

TEST A18 DATE 5/9/75 TIME 0215

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	Fwd Blower Rm #2
Location Within Compartment	at table	between blowers
Closest Distance to RADIAX, ft.		9'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	35	
Receiver Input Power, dBw	-98	
Calculated Coupling Loss	89.9 dB	

TEST A19 DATE 5/9/75 TIME 0230

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	EOS	Engine Rm
Location Within Compartment	at table	between engines
Closest Distance to RADIAX, ft.		6'
Signal Quality		good
Attenuator Setting, dB	60	
Receiver Detector Current, μA	45	
Receiver Input Power, dBw	-96	
Calculated Coupling Loss	24.8 dB	

TEST B1 DATE 5/9/75 TIME 2015

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	Repair 3	Shaft Alley #1
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.		9"
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	12	
Receiver Input Power, dBw	-108	
Calculated Coupling Loss	44.8 dB	

TEST B1 DATE 5/9/75 TIME ________

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	Repair 3	Shaft Alley #1
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.		20"
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	20	
Receiver Input Power, dBw	-103	
Calculated Coupling Loss	39.8 dB	

<u>Note</u>: test conducted with Heliflex antenna.

TEST B2 DATE 5/9/75 TIME 2045

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	H	P
Compartment	Shaft Alley #1	Repair 3
Location Within Compartment		at table
Closest Distance to RADIAX, ft.		5'
Signal Quality		good
Attenuator Setting, dB	40	
Receiver Detector Current, μA	11	
Receiver Input Power, dBw	-114	
Calculated Coupling Loss	42 dB	

TEST B3 DATE 5/9/75 TIME 2030

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Repair 3	Shaft Alley #1
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.	5'	20"
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	4.5	
Receiver Input Power, dBw	-119	
Calculated Coupling Loss	88.8 dB	

Note: test conducted with Heliflex antenna.

TEST B3 DATE 5/9/75 TIME 2040

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Repair 3	Shaft Alley #1
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.	5'	20"
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	5	
Receiver Input Power, dBw	-117	
Calculated Coupling Loss	86.8 dB	

TEST B4 DATE 5/9/75 TIME 2050

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Shaft Alley #1	Repair 3
Location Within Compartment		at table
Closest Distance to RADIAX, ft.	9"	5'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	13	
Receiver Input Power, dBw	-112	
Calculated Coupling Loss	80 dB	

TEST B4 DATE 5/9/75 TIME 2050

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Shaft Alley #1	Repair 3
Location Within Compartment		at table
Closest Distance to RADIAX, ft.	9"	5'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	21	
Receiver Input Power, dBw	-107.5	
Calculated Coupling Loss	78.5 dB	

Note: test conducted with 0.5 watt transmitter power.

TEST B5 DATE 5/9/75 TIME 2125

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	Repair 3	Aux Mach Rm #2
Location Within Compartment	at table	fwd
Closest Distance to RADIAX, ft.		3.5'
Signal Quality		good
Attenuator Setting, dB	40	
Receiver Detector Current, μA	65	
Receiver Input Power, dBw	-93	
Calculated Coupling Loss	32.7 dB	

TEST B7 DATE 5/9/75 TIME 2140

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Repair 3	Aux Mach Rm #2
Location Within Compartment	at table	fwd aux gen
Closest Distance to RADIAX, ft.	5'	3.5'
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	8	
Receiver Input Power, dBw	-112	
Calculated Coupling Loss	64.5 dB	

TEST B7 DATE 5/9/75 TIME 2140

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Repair 3	Aux Mach Rm #2
Location Within Compartment	at table	fwd aux gen
Closest Distance to RADIAX, ft.	5'	3.5'
Signal Quality		good
Attenuator Setting, dB	10	
Receiver Detector Current, μA	22.5	
Receiver Input Power, dBw	-102.5	
Calculated Coupling Loss	75 dB	

TEST B9 DATE 5/10/75 TIME ________

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	Repair 3	Steering Room
Location Within Compartment	at table	fwd of hyd pump
Closest Distance to RADIAX, ft.		3.5'
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	38	
Receiver Input Power, dBw	-98	
Calculated Coupling Loss	50.1 dB	

TEST B10 DATE 5/10/75 TIME ________

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	H	P
Compartment	Steering Gear Rm	Repair 3
Location Within Compartment	at sqk box	at table
Closest Distance to RADIAX, ft.		5'
Signal Quality		good
Attenuator Setting, dB	20	
Receiver Detector Current, μA	30	
Receiver Input Power, dBw	-104	
Calculated Coupling Loss	67.3 dB	

TEST B11 DATE 5/10/75 TIME 0115

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Repair 3	Steering Gear Rm
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.	5'	3.5'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	12	
Receiver Input Power, dBw	-107.5	
Calculated Coupling Loss	92.6 dB	

TEST B12 DATE 5/10/75 TIME 0130

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Steering Gear Rm	Repair 3
Location Within Compartment		
Closest Distance to RADIAX, ft.	3.5'	5'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	7.5	
Receiver Input Power, dBw	-117.5	
Calculated Coupling Loss	102.6 dB	

TEST B19 DATE 5/10/75 TIME 0200

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	Repair 3	Shaft Alley #2
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.		4'
Signal Quality		good
Attenuator Setting, dB	50	
Receiver Detector Current, μA	7	
Receiver Input Power, dBw	-112.5	
Calculated Coupling Loss	35.3 dB	

TEST B20 DATE 5/10/75 TIME 0220

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Repair 3	Shaft Alley #2
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.	5'	4'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	26	
Receiver Input Power, dBw	-101.5	
Calculated Coupling Loss	77.3 dB	

TEST C1 DATE 5/10/75 TIME 0345

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	DCC	Steering Gear Rm
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.		3'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	35	
Receiver Input Power, dBw	-98	
Calculated Coupling Loss	41.3 dB	

TEST C1 DATE 5/10/75 TIME 2200

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	DCC	Steering Gear Rm
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.		38"
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	30	
Receiver Input Power, dBw	-100	
Calculated Coupling Loss	43.3 dB	

TEST C3 DATE 5/10/75 TIME 2205

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Steering Gear Rm
Location Within Compartment	at tab e	
Closest Distance to RADIAX, ft.		
Signal Quality		very poor
Attenuator Setting, dB		
Receiver Detector Current, μA	0	
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST C4 DATE 5/10/75 TIME 2215

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Steering Gear Rm	DCC
Location Within Compartment		
Closest Distance to RADIAX, ft.		2'
Signal Quality		very poor/none
Attenuator Setting, dB		
Receiver Detector Current, μA	0	
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST C5 DATE 5/10/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	DCC	Repair 3
Location Within Compartment	at table	at table
Closest Distance to RADIAX, ft.		6'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	3.6	
Receiver Input Power, dBw	-124	
Calculated Coupling Loss	55.4 dB	

Note: test conducted with power splitter removed at Repair 3.

TEST C6 DATE 5/10/75 TIME 2115

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	H	P
Compartment	Repair 3	DCC
Location Within Compartment		
Closest Distance to RADIAX, ft.		2'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	28	
Receiver Input Power, dBw	-101	
Calculated Coupling Loss	32.4 dB	

TEST C8 DATE 5/10/75 TIME 2135

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Repair 3	DCC
Location Within Compartment		
Closest Distance to RADIAX, ft.	6'	2'
Signal Quality		very poor/none
Attenuator Setting, dB		
Receiver Detector Current, μA	0	
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST C9 DATE 5/10/75 TIME 0245

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	DCC	Shaft Alley #2
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.		4'
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	8	
Receiver Input Power, dBw	-112	
Calculated Coupling Loss	34.6 dB	

TEST C10 DATE 5/10/75 TIME 2220

	TRANSMITTER	RECEIVER
Serial Number	756	755
Portable/Hardwired	H	P
Compartment	DCC	Aux Mach Rm #2
Location Within Compartment	at table	126" aft frame 132 76" from port blkhd
Closest Distance to RADIAX, ft.		45"
Signal Quality		good
Attenuator Setting, dB	20	
Receiver Detector Current, μA	10	
Receiver Input Power, dBw	-115	
Calculated Coupling Loss	41 dB	

TEST C11 DATE 5/10/75 TIME 2225

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Aux Mach Rm #2
Location Within Compartment	at table	126" aft frame 132 76" from port blkhd
Closest Distance to RADIAX, ft.	2'	45"
Signal Quality		noisy but understandable
Attenuator Setting, dB		
Receiver Detector Current, μA	0	
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST C12 DATE 5/10/75 TIME 0300

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Shaft Alley #2	DCC
Location Within Compartment	126" aft frame 132 76" from port blkhd	
Closest Distance to RADIAX, ft.		3.5'
Signal Quality		poor
Attenuator Setting, dB	0	
Receiver Detector Current, μA	5.5	
Receiver Input Power, dBw	-124	
Calculated Coupling Loss	76.6 dB	

TEST ______ DATE ______ TIME ______

	TRANSMITTER	RECEIVER
Serial Number		
Portable/Hardwired		
Compartment		
Location Within Compartment		
Closest Distance to RADIAX, ft.		
Signal Quality		
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST P1 DATE 5/11/75 TIME 0145

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	DCC	Fwd Blower Rm #1
Location Within Compartment	at table	between blowers
Closest Distance to RADIAX, ft.		86"
Signal Quality		good
Attenuator Setting, dB	40	
Receiver Detector Current, μA	28	
Receiver Input Power, dBw	-101	
Calculated Coupling Loss	33.7 dB	

TEST P2 DATE 5/11/75 TIME 0200

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	H
Compartment	Fwd Blower Rm #1	DCC
Location Within Compartment	between blowers	
Closest Distance to RADIAX, ft.	86"	
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	25	
Receiver Input Power, dBw	-106	
Calculated Coupling Loss	50 dB	

TEST P3 DATE 5/11/7 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Fwd Blower Rm #1
Location Within Compartment		between blowers
Closest Distance to RADIAX, ft.	2'	86"
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	21	
Receiver Input Power, dBw	-103	
Calculated Coupling Loss	78.8 dB	

TEST P4 DATE 5/11/75 TIME 0155

	TRANSMITTER	RECEIVER
Serial Number	755	756
Portable/Hardwired	P	P
Compartment	Fwd Blower Rm #1	DCC
Location Within Compartment	between blowers	
Closest Distance to RADIAX, ft.	86"	2'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	35	
Receiver Input Power, dBw	-104	
Calculated Coupling Loss	78 dB	

TEST P5 DATE 5/11/75 TIME 0115

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	DCC	Fire Room
Location Within Compartment	at table	level with fire rm sta; between boilers
Closest Distance to RADIAX, ft.		10'
Signal Quality		good with noise
Attenuator Setting, dB	40	
Receiver Detector Current, μA	25	
Receiver Input Power, dBw	-102	
Calculated Coupling Loss	37.7 dB	

TEST P6 DATE 5/11/75 TIME 0205

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	H
Compartment	Fire Room	DCC
Location Within Compartment	level with fire rm sta; between boilers	
Closest Distance to RADIAX, ft.	10'	
Signal Quality		good
Attenuator Setting, dB	30	
Receiver Detector Current, μA	32.5	
Receiver Input Power, dBw	-103	
Calculated Coupling Loss	48.7 dB	

TEST P7 DATE 5/11/75 TIME 0135

	TRANSMITTER	RECEIVER
Serial Number	756	755
Portable/Hardwired	P	P
Compartment	DCC	Fire Room
Location Within Compartment		level with fire rm sta; between boilers
Closest Distance to RADIAX, ft.	2'	10'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	7	
Receiver Input Power, dBw	-120	
Calculated Coupling Loss	98.7 dB	

TEST P8 DATE 5/11/75 TIME 0120

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Fire Room	DCC
Location Within Compartment	level with fire rm sta; between boilers	
Closest Distance to RADIAX, ft.	10'	2'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	8	
Receiver Input Power, dBw	-117.5	
Calculated Coupling Loss	96.2 dB	

TEST P9 DATE 5/11/75 TIME 0030

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	DCC	Fire Room
Location Within Compartment		lowest level; between boilers
Closest Distance to RADIAX, ft.		4'
Signal Quality		good
Attenuator Setting, dB	40	
Receiver Detector Current, μA	10	
Receiver Input Power, dBw	-109	
Calculated Coupling Loss	44.7 dB	

TEST P11 DATE 5/11/75 TIME 0105

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Fire Room
Location Within Compartment		lowest level; between boilers
Closest Distance to RADIAX, ft.	2'	4'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	5	
Receiver Input Power, dBw	-116	
Calculated Coupling Loss	94.7 dB	

TEST P12 DATE 5/11/75 TIME 0111

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Fire Room	DCC
Location Within Compartment	lowest level; between boilers	
Closest Distance to RADIAX, ft.	4'	2'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	8.5	
Receiver Input Power, dBw	-116	
Calculated Coupling Loss	94.7 dB	

TEST P13 DATE 5/11/75 TIME 0220

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	DCC	Repair Parts Storeroom
Location Within Compartment		by freezer door
Closest Distance to RADIAX, ft.		12'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	65	
Receiver Input Power, dBw	-93.5	
Calculated Coupling Loss	53.9 dB	

TEST P14 DATE 5/11/75 TIME 0245

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	H
Compartment	Repair Parts Storeroom	DCC
Location Within Compartment	by freezer door	
Closest Distance to RADIAX, ft.	12'	
Signal Quality		good
Attenuator Setting, dB	10	
Receiver Detector Current, μA	45	
Receiver Input Power, dBw	-100.5	
Calculated Coupling Loss	50.9 dB	

TEST P15 DATE 5/11/75 TIME 0235

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Repair Parts Storeroom
Location Within Compartment		by freezer door
Closest Distance to RADIAX, ft.	2'	12'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST P16 DATE 5/11/75 TIME 0240

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Repair Parts Storeroom	DCC
Location Within Compartment	by freezer door	
Closest Distance to RADIAX, ft.	12'	2'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST P21 DATE 5/11/75 TIME 0320

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	Fire Rm Control Sta
Location Within Compartment		center of room
Closest Distance to RADIAX, ft.	5'	3'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	9	
Receiver Input Power, dBw	-110	
Calculated Coupling Loss	96.9 dB	

TEST P22 DATE 5/11/75 TIME 0340

	TRANSMITTER	RECEIVER
Serial Number	757	755
Portable/Hardwired	P	P
Compartment	Fire Rm Control Sta	EOS
Location Within Compartment	center of room	
Closest Distance to RADIAX, ft.	3'	5'
Signal Quality		
Attenuator Setting, dB	0	
Receiver Detector Current, μA	15	
Receiver Input Power, dBw	-111	
Calculated Coupling Loss	97.9 dB	

TEST P23 DATE 5/11/75 TIME 0305

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	H	P
Compartment	EOS	Aux Mach Rm #2
Location Within Compartment	at table	stbd area
Closest Distance to RADIAX, ft.		2'
Signal Quality		good
Attenuator Setting, dB	0	
Receiver Detector Current, μA	22	
Receiver Input Power, dBw	-103	
Calculated Coupling Loss	53.8 dB	

TEST X1 DATE 5/11/75 TIME 2045

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Steering Gear Room
Location Within Compartment		
Closest Distance to RADIAX, ft.	2.5'	39"
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X3 DATE 5/11/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Steering Gear Room	EOS
Location Within Compartment		midships
Closest Distance to RADIAX, ft.	39"	4'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X4 DATE 5/11/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	Steering Gear Room
Location Within Compartment	midships	
Closest Distance to RADIAX, ft.	4'	39"
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X5 DATE 5/11/75 TIME 2130

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	Torpedo Room
Location Within Compartment	midships	middle
Closest Distance to RADIAX, ft.	4'	2.5'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X6 DATE 5/11/75 TIME 2140

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Torpedo Room	EOS
Location Within Compartment	middle	midships
Closest Distance to RADIAX, ft.	2.5'	4'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, µA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X7 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	Repair 3
Location Within Compartment	midships	at table
Closest Distance to RADIAX, ft.	4'	6'
Signal Quality		good, little noise
Attenuator Setting, dB		
Receiver Detector Current, µA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X8 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Repair 3	EOS
Location Within Compartment	at table	midships
Closest Distance to RADIAX, ft.	6'	4'
Signal Quality		poor
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X9 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Repair 3
Location Within Compartment	at table	at table
Closest Distance to RADIAX, ft.	3'	6'
Signal Quality		no communication
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X10 DATE 5/11/75 TIME ____

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Repair 3	DCC
Location Within Compartment	at table	at table
Closest Distance to RADIAX, ft.	6'	3'
Signal Quality		no communication
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

Note: no communication with transmitter power of 1.0 watt.

TEST X11 DATE 5/11/75 TIME ____

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Torpedo Room
Location Within Compartment	at table	middle
Closest Distance to RADIAX, ft.	3'	2.5'
Signal Quality		no communication
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

Note: good signal with transmitter power of 0.5 watt.

TEST X12 DATE 5/11/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Torpedo Room	DCC
Location Within Compartment	middle	
Closest Distance to RADIAX, ft.	2.5'	
Signal Quality		clear but with dead spots
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X13 DATE 5/11/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	756	755
Portable/Hardwired	P	P
Compartment	DCC	Aux Mach Rm #2
Location Within Compartment	at table	port side
Closest Distance to RADIAX, ft.	3'	45"
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X14 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Aux Mach Rm #2	DCC
Location Within Compartment	port side	at table
Closest Distance to RADIAX, ft.	45"	3'
Signal Quality		clear but with dead spots
Attenuator Setting, dB		
Receiver Detector Current, µA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X15 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	EOS	Aux Mach Rm #2
Location Within Compartment	midships	port side
Closest Distance to RADIAX, ft.	4'	45"
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, µA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X16 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Aux Mach Rm #2	EOS
Location Within Compartment	port side	midships
Closest Distance to RADIAX, ft.	45"	4'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, µA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X17 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Shaft Alley #2
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.	3'	3.5'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, µA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X18 DATE 5/11/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Shaft Alley #2	DCC
Location Within Compartment	at aft bearing	at table
Closest Distance to RADIAX, ft.	3.5'	3'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X19 DATE 5/11/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	DCC	Shaft Alley #1
Location Within Compartment	at table	
Closest Distance to RADIAX, ft.	3'	1'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X20 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Shaft Alley #1	DCC
Location Within Compartment		at table
Closest Distance to RADIAX, ft.	1'	3'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X21 DATE 5/11/75 TIME

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Electric Central	Repair 3
Location Within Compartment	at door	
Closest Distance to RADIAX, ft.	8'	
Signal Quality		poor
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X22 DATE 5/11/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	756	757
Portable/Hardwired	P	P
Compartment	Repair 3	Electric Central
Location Within Compartment		at door
Closest Distance to RADIAX, ft.		8'
Signal Quality		poor
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

TEST X23 DATE 5/11/75 TIME ______

	TRANSMITTER	RECEIVER
Serial Number	757	756
Portable/Hardwired	P	P
Compartment	Repair 3	Aux Mach Rm #1
Location Within Compartment		
Closest Distance to RADIAX, ft.		6'
Signal Quality		good
Attenuator Setting, dB		
Receiver Detector Current, μA		
Receiver Input Power, dBw		
Calculated Coupling Loss		

DISCUSSION

The test data and all calculated coupling loss data are divided into one-way wireless (one hard-wired transceiver the other portable) and two-way wireless (both transceivers portable).

Coupling losses under one-way and two-way conditions have been segregated and tabulated with respect to the nearest distance between the transceiver antenna(e) and the Radiax cable (tables 1 and 2).

Table 1
One-Way Coupling Losses Versus Distance

distance, in	calculated coupling loss, dB
9	44.8
18	53.7
20	39.8
24	53.8, 32.4
34	41.6
36	41.3
38	43.3
42	32.7, 50.1
45	41
48	36.2, 34.6, 44.7
60	42
72	40.5, 55.4, 47.9, 33.9
86	33.7
108	43.8, 85.4
120	37.7
144	50.9

Table 2
Two-Way Coupling Losses Versus Distance

distance, in	calculated coupling loss, dB
69	78.5, 80
72	94.7, 94.7
80	88.8, 86.8
96	91.4, 89.4, 96.9, 97.9
102	64.5, 92.6, 102.6
106	66.8, 67.6
108	77.3
110	78
120	68.7
144	96.2, 98.7
168	87.4
180	80.5

The calculated coupling losses versus distance for both one-way and two-way tests have been plotted in figures 7 and 8 respectively.

Examination of figures 7 and 8 reveals the following:

- Typical (average) coupling loss for a one-way condition is about 45 dB.

- Typical (average) coupling loss for a two-way condition is about 85 dB

- Coupling loss for the two-way condition is approximately twice that for the one-way condition.

- Coupling loss does not appear to increase with increasing distance; and is relatively independent of distance for the distances measured.

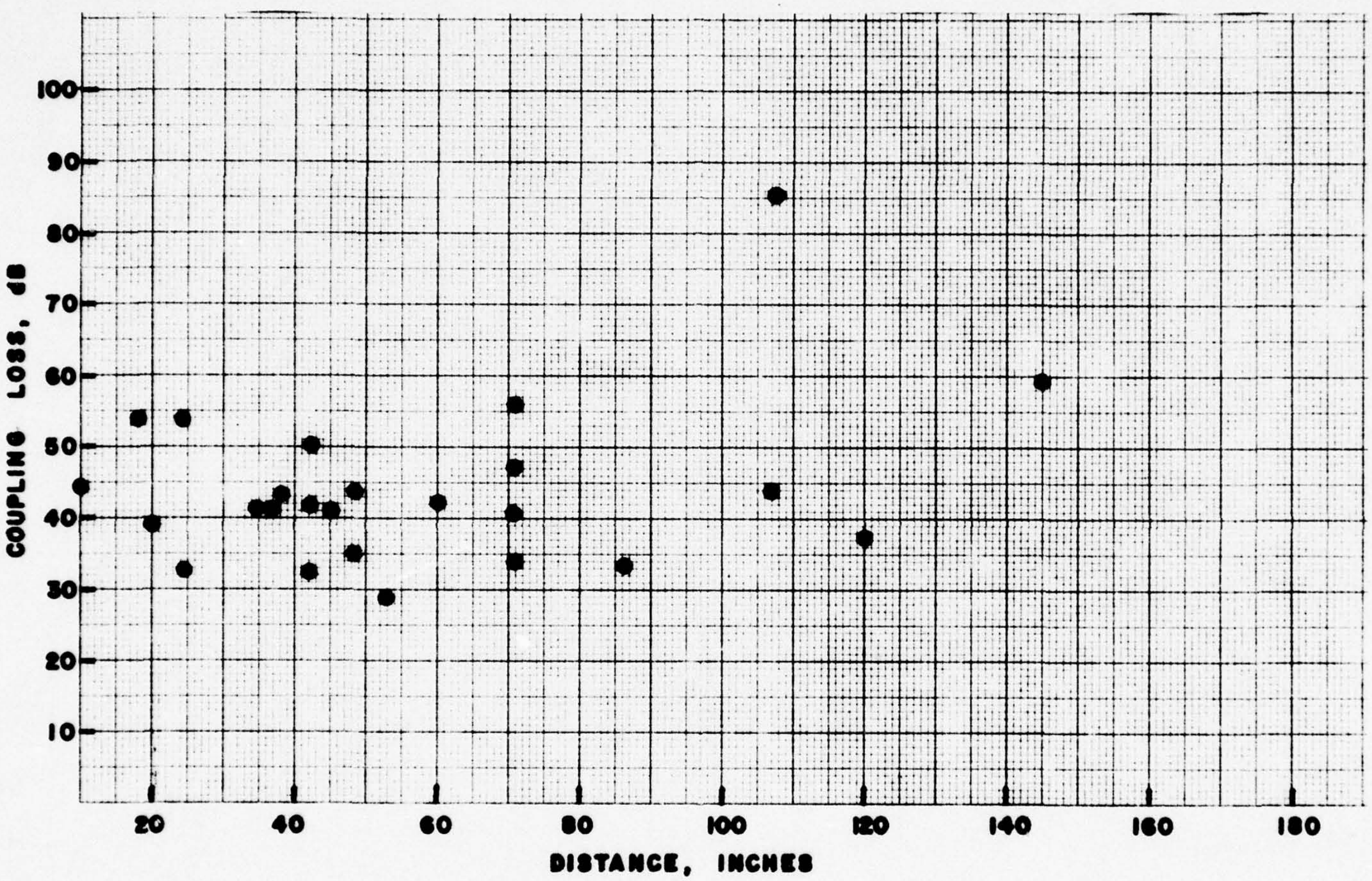

Figure 7
Coupling Loss Versus Distance
(One-Way)

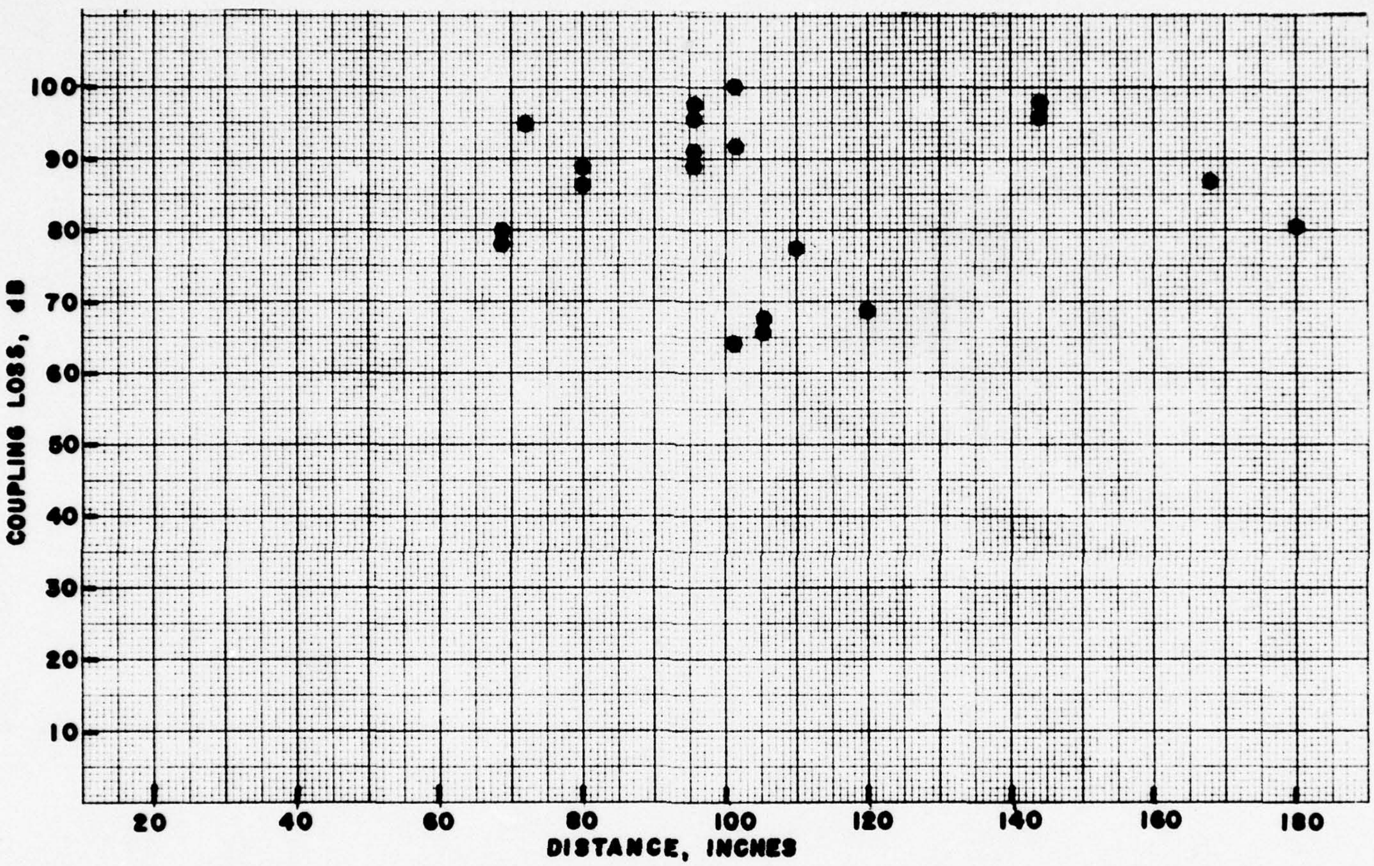

Figure 8
Coupling Loss Versus Distance
(Two-Way)

Tests A15, A19, and B19 required an external signal attenuation of over 40 dB in order to reduce signal amplitude within calibration limits. These tests were considered to be of marginal relevance because for high attenuation of say 40 dB or more, the transceivers would have to be completely shielded. A portion of the transmitted or received signal enters the transceiver input directly through the transceivers' plastic housing (bypassing the transceiver antenna). The results of these three tests have been deleted from the plots in figures 7 and 8.

Examination of system tests data indicate there are eight tests where the test conditions satisfy the requirements for reciprocity determination. Reciprocity is demonstrated when the coupling loss is not affected after the transmitter and receiver roles are interchanged while keeping all other parameters constant. The tests applicable to reciprocity determination and their results are shown in table 3.

TABLE 3
DATA FOR RECIPROCITY DETERMINATION

TEST NO.	TWO-WAY COUPLING LOSS dB	ΔdB
A3 - A4	67.6 - 66.8	0.8
A11 - A12	91.4 - 89.4	2.0
B11 - B12	92.6 - 102.6	10.0
P3 - P4	78.8 - 78.0	0.8
P7 - P8	98.7 - 96.2	2.5
P11 - P12	94.7 - 94.7	0.0
P13 - P14 *	53.9 - 50.9	3.0
P21 - P22	96.9 - 97.9	1.0

* One way coupling loss

The results of the tests shown in table 3 substantiate reciprocity i.e., the two coupling loss measurements with transmitter - receiver roles interchanged are close enough to indicate no substantial change (ΔdB) for either coupling loss measurement.

The largest variation (10 dB) could be accounted for by changes in the propagation environment as personnel opened and closed hatches or due to a measurement error.

The "X" series of tests show there are cases where no two-way communication exists between two given points. This is only true for cases when the fwd and aft cable routes have been combined and while large Radiax cable lengths are involved (tests X9, X10, and X11). The "X" series of tests were conducted with the two transceivers in motion in order to more realistically simulate the expected conditions, and no attention was given to the distance between the cable and transceivers. Communication between some points was marginal under fixed conditions (see tests X9 and X10 versus test C8). This marginal communication condition is attributed to shorter cable-to-transceiver distances as compared with the "X" series of tests where the two units were in motion.

CONCLUSIONS

In this installation there was no attention given to the requirements of separating the Radiax cable at least 0.5 inches from all metal surfaces. Thus, the cable attenuation loss for the RX4-3 cable which measures 1.9 dB/100 ft in open space was found to be 6.6 dB/100 ft as an average over a total distance of 991 feet. The coupling losses were also affected by the close proximity of the Radiax cable to the metal surfaces. Shipboard tests under these conditions resulted in one-way coupling losses averaging about 45 dB at a frequency of approximately 140 MHZ.

The Andrew Corporation specification sheet for Radiax cable indicates a one-way coupling loss of 57±10 dB at 150 MHZ for open space measurements and the coupling loss is found to be greatly influenced by operating frequency and cable-metal proximity. Measurements made by the Andrew Corporation in a tunnel with the Radiax cable mounted against a metal surface are in general agreement with the cable attenuation measurements aboard ship.

From shipboard tests of the wireless internal ship communications system aboard the destroyer escort DE1094 the following conclusions have been determined:

- With a transmitted power of 0.25 watts which was used during the majority of the tests there is excellent communication in all locations served by the cable when the system is operated in the one-way wireless mode, i.e., one transceiver hard-wired to the cable the other wireless.

- Two-way wireless operation at 0.25 watts with no connections whatever to the cable is marginal depending on the distance from the cable and the separation of the two portable transceivers. However, two-way performance with the Radiax cable is improved compared to that before the cable was installed permitting communication in areas totally isolated from wireless communications before the installation of Radiax.

To achieve acceptable two-way wireless operation in all areas would probably require that both transceiver antennas be positioned within a few feet of the cable when communicating over the extreme length of the system at 0.25 watts or an optimum location found relative to the cable.

- Transceiver antenna orientation has a relatively minor effect on coupling loss, hence on communication capability. Signal strength and coupling loss vary considerably even for changes of fractions of a foot within the all enclosed steel compartments of a ship. This indicates that additions and cancellations are occuring within the complex propagation pattern where an entire compartment is flooded with electromagnetic energy and multiple reflections occur off compartment sides, piping, machinery etc.

Even though coupling loss varies from point to point, there is still no discernable overall trend of coupling loss variation versus distance from the Radiax cable. For example, coupling loss at distances of 2, 5 or 10 feet may be identical, but with large variations in between.

- Conversion of the transceivers used in these tests to read detected second mixer output current for signal strength measurements affected the receiver sensitivity due to loading by the detector circuit at a high gain point of the receiver. However, the coupling loss measurements are unaffected since they are independent of the signal level and are therefore as accurate as the measurement error and test technique permits.

The loss in receiver gain caused by the measurement modification could result in a gain loss of from 6 to 30 dB. Assuming the receiver requires full gain to amplify the minimum detectable signal (nominally 0.35 microvolts) to a usable audio level, a gain loss of 30 dB would require an input signal level of 11 microvolts to achieve the same output level. The Motorola engineering department found a signal sensitivity loss of over 6.5 dB on a modified HT220 transceiver. Since this modification is difficult to repeat exactly due to lead and component lengths and positions, the modified receivers could have been changed by at least 6 dB or up to 30 dB.

Summarizing the modification-gain change problem - coupling loss measurements are correct, but the qualitative results of communication ability in various locations are probably quite pessimistic for these tests.

• Two-way wireless communication could be achieved at 0.25 watts power with the same success as was found using one-way wireless communications by the installation of a 0.25 watt repeater in the Radiax cable. Since the coupling losses were shown to be reciprocal, the installation of such a repeater (though not done in these tests) would permit two-way wireless operation with only a one-way effective coupling loss. On the average the one-way coupling loss was about 45 dB so that with a repeater system excellent communication could be obtained at any location even between extreme ends of the cable.

Low cost repeater equipment is currently available in these power ranges for continuous duty operation and with various options such as carrier actuated transmitter, adjustable time out protective circuitry, and standby power provisions.

Should a catastrophic failure occur in the repeater, communication would revert to the two-way wireless passive mode and the operators would be aware immediately of the failure by a change in the paging characteristics unique to repeater systems.

APPENDIX A

APPENDIX B

APPENDIX B

EVALUATION OF PORTABLE CAPABILITY, 3-5
JUNE 1975

1	2
Start Power: 1.0 W	Start Power: 2.5W
RECEIVING STATION (PORTABLE)	MOBILE STATION (PORTABLE)

<u>SYSTEM CONNECTED IN SHAFT ALLEY #1</u>

			1 2 COMMS QUALITY
Repair #3	1.	Shaft Alley #1	LC*

<u>SYSTEM DISCONNECTED*</u>

Repair #3	1.	Torpedo Room	LC
	2.	1st Class Lounge	LC
	3.	Steering Gear Room	LC
	3a.	Port Passageway	LC
	4.	Passageway 5-147-1-L	LC
	5.	Passageway Aft & Adjacent to Landing Force Gear Room.	L & Readable (Some background noise, depending on location & antenna orientation)
	6.	Aux Mach #2-Entrance	LC
	6a.	Aux Mach #2A	LC
	6b.	Aux Mach #2B	LC
	7.	Pump Room	LC
	8.	Chem WFE STRM	LC

* No 50 OHM Load Connectors on Aft System

<u>SYSTEM DISCONNECTED**</u>

Repair #3	1.	Shaft Alley #2	LC
	2.	Crew's Living Space	LC
	2a.	Starboard Side	L & Readable (Some faded spots w/background noise.)
	2b.	Port Side	L& Readable (Some faded spots w/background noise.)
	3.	OOD Station	LC

***LC: Loud and Clear**

RECEIVING STATION (PORTABLE)[1]	MOBILE STATION (PORTABLE)[2]	COMMS QUALITY[1] [2]
	SYSTEM DISCONNECTED**	
	4. SD Stores 4-107-1-A	
	4a. Upper level	L & Readable (Some faded spots w/background noise)
	4b. Lower level	L & Some transmissions faded out completely
	5. Adjacent to Refrigerators	LC
	6. Refrigeration Mach Room	LC
	7. Shaft Alley #1	LC
Power Level (.9W)	Power Level (2.1W)	

** No 50 OHM Load Connectors on Aft System

	SYSTEM CONNECTED***	
Power Level (.9W)	Power Level (.8W) Different Radio	
Repair #3	1. OOD Station	LC
	2. Adjacent to Barber Shop & Post Office	LC
	3. Steering Gear Room Watch Station Aft (Furtherest Point)	LC
	4. CPO Lounge	LC
	5. Landing Force Gear Rm	LC
	6. Aux Mach #2	LC
	6a. Aux Mach #2A	LC
	6b. Aux Mach #2B	LC
	7. Chem WFE Storeroom	LC
	8. Shaft Alley #2	LC
	9. Refrigeration Rooms	LC
	10. Refrig. Mach Room	LC
Power Level (.94W)	Power Level (.76W) Spare Power Level (2.4W)	

***Load Connections both ends of system

1	2		
RECEIVING STATION (PORTABLE)	MOBILE STATION (PORTABLE)		

SYSTEM CONNECTED

			1 COMMS	2 QUALITY
Damage Control Central	1.	Electric Central	LC	
	2.	General Workshop	LC	
	3.	Aux Mach #1	LC	
	3a.	Aux Mach #1 (lower level)	LC	
	4.	Fire Room		
		a. Mid Level (Fwd/ STBD Side) Between Boilers	Not Readable	
		b. Lowest Level Between Boilers	Not Readable	
		c. Upper Level Between Boilers		
		1.0W Power Lev	Not Readable	
		2.2W " "	L & Readable but faded spots	
		5.0W " "	LC	
	5.	Passageway adjacent to officer country - portside	LC	
	6.	FD Blower Room #1	Not Readable	
	7.	Passageway in officer country 1-95-4-L	Not Readable	
	8.	EOS	LC	
	9.	Engine Rm (Mid Level) w/background noise and fading	Readable	
	10.	Engine Rm (Lower Level) Orientation effect noted	Not Readable	
		2' from cable	LC	
	11.	Mess Deck	LC	
	12.	SD Stores 1.0W P.L.	Not Readable	
		5.0W P.L.	Readable	
	13.	Refrig Mach Room		
		1.0W	Not Readable	
		5.0W	Readable	
	14.	Aux Mach Rm #2	Not Readable	
	15.	Aux Mach Rm #2A	Not Readable	
	16.	Aux Mach Rm #2B	Not Readable	
	17.	Repair #3	Not Readable	

Power Level (1.10W)

Power Level (.72W)
Spare (2.1W)

DISCONNECTED

Removed from EOS

1 (Portable)		2 (Portable)	
EOS	1.	Engine Room	LC
	2.	Fire Room	LC
	3.	FWD Blower Room	
		#1	LC
		#2	LC
	4.	Passageway - adjacent to officers country	LC
	5.	Inner Passageway	LC
	6.	Aux Mach Rm #1	LC
	7.	Damage Control Central	LC
	8.	General Workshop	LC
	9.	Electric Control	LC
	10.	SD Storeroom	LC
	11.	Refrig Mach Room	LC
	12.	Passageway aft of DCC Main Deck	LC

CONNECTED

1 (Portable)		2 (Portable)	
EOS	1.	Shaft Alley #1	LC
	2.	SD Store Room	LC
	3.	Ref Mach Room	LC
	4.	Crew's Living Space	LC
	5.	Aux Mach #2	LC
	6.	Chem WFE Equip Rm	LC
	7.	Aux Mach #2A	LC
	8.	Aux Mach #2B	LC
	9.	Pump Room	LC
	10.	Torpedo Room	LC
	11.	Steering Gear Room	LC
Power Level (1.10W)		Power Level (1.06W) Spare (2.5W)	

SYSTEM CONNECTED

Port OOD Station

1 (H/W)		2 (Portable)	
	1.	External Main Deck	LC
	2.	FPO	LC
	3.	Torpedo Room	LC
	4.	Steering Gear Room	LC
	5.	Log for gear Strm	LC
	6.	Aux #2	LC
	7.	Crew's Living Space (1st Platform)	LC
	8.	SD Storeroom	LC
	9.	Refrig Mach Room	LC
	10.	Mess Deck	LC
	11.	Engine Room	LC
	12.	EOS	LC
	13.	Fire Room	LC
	14.	FD Blower Room 1&2	LC
	15.	Aux #1	LC
	16.	OCC	LC
	17.	Repair #2	Not Readable
	18.	Crew's Lounge (2nd deck)	Not Readable
	19.	Electric Central	LC
		a. General Workshop	LC
		b. Crew's Living Space	LC

APPENDIX C

APPENDIX C

RESULTS OF COMMUNICATION CAPABILITY TESTING WITHOUT RADIAX CABLE, 20 OCT 1974

This appendix contains the results of tests to determine communication capability aboard the U.S.S. PHARRIS prior to Radiax installation. The tests were conducted between two portable, hand-held, Motorola HT220 transceivers operating in the 140 MHz range; both 1-watt and 5-watt transmitter output power levels were used. Two separate tests were conducted: one under material condition YOKE, the other under material condition ZEBRA. The results of these tests are tabulated in the following two pages.

Transceiver #1 Compartment & Location \ Transceiver #2 Compartment & Location	Main Deck 1-46-2 #15	Main Deck 1-89-2 #14	Main Deck 1-46-1 #16	Main Deck 1-87-1 #19	Pier Approx Pr 60	Damage Control Ctr	Electric Central between switchboards	Aux Mach Rm #1 upper lev at fwd ladder	Aux Mach Rm #1 lowest lev at fwd ladder	Fire Room lowest level between boilers	Engine Room 5-95-O-E control station	Shaft Alley #1 at bottom of ladder	Shaft Alley #2 at bottom of ladder	Aux Mach Rm #2 center	Aux Mach Rm #2 stbd area - center	Repair 3 center	Torpedo Room front of VDS room	Steering Room at control station	Main Deck 1-105-2 #4	Main Deck 1-105-1 #5	Main Deck 1-124-2 #3	Main Deck 1-139-2 #2	Main Deck 1-120-1 #6	Main Deck 1-139-1 #7
Damage Control Ctr center				no 5w	no 5w			yes 1w	yes 1w	yes 1w	yes 1w	no 1w	no 1w	no 1w	no 1w	yes 5w	no 1w	no 1w						
Repair 3 center					yes 1w		very poor 5w	no 5w	no 5w	no 5w	yes 1w	yes 1w	yes 1w	yes 1w	yes 1w		yes 1w	yes 1w						
Engine Room control station							yes 1w	yes 1w	yes 1w	yes 1w		yes 1w	yes 1w	very poor 1w	yes 1w		no 1w	yes 1w						

Material Condition YOKE

Transceiver #1 Compartment & Location \ Transceiver #2 Compartment & Location	Main Deck 1-46-2 #15	Main Deck 1-89-2 #14	Main Deck 1-46-1 #16	Main Deck 1-87-1 #19	Pier Approx Fr 60	Damage Control Ctr	Electric Central between switchboards	Aux Mach Rm #1 upper lev at fwd ladder	Aux Mach Rm #1 lowest lev at fwd ladder	Fire Room lowest level between boilers	Engine Room 5-95-O-E control station	Shaft Alley #1 at bottom of ladder	Shaft Alley #2 at bottom of ladder	Aux Mach Rm #2 center	Aux Mach Rm #2 stbd area - center	Repair 3 center	Torpedo Room front of VDS room	Steering Room at control station	Main Deck 1-105-2 #4	Main Deck 1-105-1 #5	Main Deck 1-124-2 #3	Main Deck 1-139-2 #2	Main Deck 1-120-1 #6	Main Deck 1-139-1 #7
Damage Control Ctr center	yes	yes	yes	yes			yes 1w	yes 1w	yes 1w	no 1w	yes 1w	no 1w	no 1w	no 1w	no 1w	no 1w	no 1w	no 1w						
Repair 3 center							no 1w	no 1w	no 1w	no 1w	no 1w	no 1w	yes 1w	yes 1w	yes 1w		yes 1w	yes 1w			yes 1w	yes 1w	yes 1w	yes 1w
Engine Room control station							yes 1w	yes 1w	yes 1w	yes 1w		yes 1w	yes 1w	no 5w	no 5w		no 5w	very poor 5w	yes 1w	yes 1w				

Material Condition ZEBRA